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EDITED BY NICHOLAS MURRAY BUTLER

THE TEACHING OF PHYSICS

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THE TEACHING OF PHYSICS

FOR

PURPOSES OF GENERAL EDUCATION

BY

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TO MY

FATHER AND MOTHER

WHOSE WISE AND PRACTICAL INTERPRETATION

OF LIFE

MADE THIS BOOK POSSIBLE

AUTHOR'S PREFACE

ONE of the liveliest themes of present educational discussion is that of the distinction between vocational and cultural work. According to the old ideas, certain subjects are preëminently cultural, while others are distinctly vocational; and in any scheme of general education, the cultural studies must predominate. The present insistent demand for industrial training has brought these ideas into the limelight of investigation, and has divided the forces of education into two parties, which may be called the culturalists and the vocationalists.

This distinction between cultural and vocational seems to be wholly beside the mark in any true system of general education. It owes its origin to the mistaken ideas of the doctrine of formal discipline. This book is an effort to show how, in the case of physics, the two points of view may be amalgamated into one. The fundamental thesis of this union has been stated by President G. Stanley Hall, in his *Educational Problems*, in the following words (Vol. I, p. 614): "In point of fact, we psychologists must make the mortifying con-

fession that we know almost nothing of pure culture values, either what they are or how to acquire them. But we do know that to succeed an individual must put his whole soul into his work, and that the study of even Greek, Latin, and logic in a half-hearted way is demoralizing and soporific. We know, too, that if most men do not find culture value in their own vocation they will never find it. Anything is cultural that arouses the ambition of young people to do their best; hence whether a topic is cultural or practical depends wholly upon the point of view and the spirit."

The book is divided into three parts. The first of these traces the development of the present situation. The second traces the origin of physics, and seeks to establish its leading characteristics and to define its possibilities as a means of general education. In the third part the purpose of physics teaching is stated, and hints are given as to how this purpose may be attained.

The physics teacher will doubtless find this third part unsatisfactory in that it gives few specific directions as to how to proceed. The reason for this is obvious. Physics teaching has suffered in the past from over-specification. While it is true that young teachers want to be told in detail just what to do, it is equally true that such detailed instructions are a very serious obstacle to effective work. Every successful teacher

must think for himself and adapt his work to his special environment. A detailed specification of just what to do is incompatible with the educational ideas expressed in this book.

In addition to the references given as footnotes to the text, the chapters in Parts II and III are supplied with lists of "collateral reading." In order to make these lists brief, they include in general only references to works published within the past ten or twelve years. Older works are included when they contain material that has not been dealt with more briefly in recent writings.

The author wishes here to express his sense of deep obligation to the many hundred physics teachers who, by correspondence and discussion, have contributed ideas to the New Movement among Physics Teachers, of which this book is the outcome. He also wishes especially to record his obligation to the editor of this series, President Nicholas Murray Butler, of Columbia University, and to Professor J. F. Woodhull, of Teachers College, New York, Professor O. W. Caldwell of the University of Chicago, and Professor G. R. Twiss, of Ohio State University, for their many valuable criticisms and suggestions made while the book was in manuscript and in press.

C. R. MANN.

THE UNIVERSITY OF CHICAGO,
January, 1912.

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EDITOR'S INTRODUCTION

THERE is a good deal to be said on the subject of teaching physics in secondary schools and to students of the elements of physical science in colleges, that can properly be said by one who, though not a physicist, is an observer and student of contemporary educational conditions and problems. Certain fundamental principles ought to be assumed.

1. The topics chosen and the method pursued should be determined by the intellectual needs and interests of pupils of secondary school age, and not by some preconceived notion as to what those needs and interests ought to be. College admission tests in physics should be made to depend upon the secondary school teaching of that subject, when properly organized and conducted, and not *vice versa.*

2. The teacher should put out of his mind the thought that each pupil before him is aiming to become a specialist in physical science, or that the study of physics is his main interest in life.

3. Physical science should not be presented as something fixed and definite, whose conclusions are final, but

rather as a division of organized knowledge which is constantly expanding and developing and which has frequently, within historic times, corrected its conclusions in the light of later discoveries. To this end some outline of the history of physical science and of the time and order in which its fundamental laws were discovered and developed should be given to the student. Wherever it is possible to relate the discovery or new application of a physical principle to man's other activities, this should be done in order that the student may be made to feel from the beginning the intimate relation between the laws and phenomena with which physics deals, and other human interests. In other words, the teaching of physics should be humanized.

4. As a farther step in the humanizing of physics teaching, the pupil should be brought to know something of the men whose names are epoch-marking in the history of physical science. Such names as those of Archimedes, Galileo, Newton, Kepler, Gauss, Young, Gay-Lussac, Davy, Faraday, Helmholtz, Kelvin, Torricelli, Ampère, Joule, Mayer, Fresnel, Galvani, Volta, should be familiar to the student, and he should be able to tell something of who these men were, when they lived, and what they did which causes them to be remembered in the history of science.

5. By material drawn from the third book of John Stuart Mill's "Logic," or from Professor Jevons's "Prin-

ciples of Science," the skillful teacher may so interest the student in his laboratory problems that the student will come to understand clearly the significance of the inductive method, of the verification of hypotheses, and of the formulation of so-called laws of nature.

6. The ordinary standards for measuring time, space, weight, and other characteristics, should not be taken for granted, but their origin and history should be made plain and their fundamental principles discussed. Under this head I would include also the thermometer, the barometer, the microscope, the telescope, and the spectroscope.

7. It is difficult for one not himself a physicist to make any profitable suggestions as to the subjects to be selected for presentation to students of physics in secondary schools. In general, however, it may safely be held that these subjects should be those general ones which relate in an elemental or fundamental way to transformations of energy. The tendency observable in many school textbooks to pursue these subjects into very refined and subtle inferences, is to be deprecated. Taught in this way the beginner loses his sense of perspective and physics repels rather than attracts him.

8. Far too much has been made in recent years of accuracy of measurement in the teaching of elementary physics. It is much more important to throw emphasis upon the descriptive aspects of the science and to feed

the growing mind with food that really interests it and helps it to grow, than to pursue the will-o'-the-wisp of training some imaginary power of habitual accuracy. Accurate measurements have their place in the teaching of elementary physics, but that place is a subordinate one. The main task is to teach the constitution